Clark County Volunteer Monitoring Program
Lake Monitoring Manual

A program supported by
Clark County Public Works Water Resources

Funding provided by the
Clark County Clean Water Program
and
Washington Department of Ecology Water Quality Grant

CLARK COUNTY VOLUNTEER MONITORING PROGRAM
LAKE MONITORING MANUAL

Collecting water samples from Lacamas Lake

Learning about lake ecology at the Lacamas Lake County Park kiosk

Secchi dipping at Yale Reservoir on the N. fork Lewis River

CLARK COUNTY VOLUNTEER MONITORING PROGRAM
LAKE MONITORING MANUAL

Welcome to Clark County's volunteer monitoring program. We are excited to get you involved! Our program relies on volunteers working directly in a county monitoring program, with interest in specific issues or regions within the county. Regardless of where you choose to monitor, this manual will provide a means to get you to the desired endpoint: credible, meaningful data that can be used by agencies and resource managers to guide resource decisions.

The **procedures** of this manual include measures of physical and chemical make-up, and biological integrity of lakes. Volunteers have access to an array of procedures, ranging from high tech monitoring equipment to visual assessments of algae and aquatic plant growth.

The **Clark County Volunteer Monitoring Program** assists citizens interested in examining the health of Clark County's water resources. We educate, equip, and escort volunteers while promoting stewardship of water and watersheds. Most importantly we want you to enjoy yourself, have fun outdoors, and learn, learn, learn…

The Clark County Volunteer Monitoring Program is run by Clark County Public Works Water Resources, with funding provided by the Clark County Clean Water Program and a Washington Department of Ecology grant.

CLARK COUNTY DEPARTMENT OF PUBLIC WORKS

ECOLOGY WATER QUALITY PROGRAM

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A word about our volunteer monitoring manual:

There are a variety of volunteer programs offering guidance and/or protocols for monitoring lakes. Our monitoring manual and program design was adopted from a manual developed by the **US Environmental Protection Agency**.

In implementing this program in Clark County we did our best to preserve the integrity of the EPA manual, only changing the parts of the manual necessary to 1) make it suitable for Clark County's monitoring objectives; and 2) to reflect available equipment and staff resources. The changes were minor and the majority of the information is presented verbatim from the **EPA's Volunteer Lake Monitoring Manual, EPA440-4-91-002**.

We thank the US EPA for presenting methods for monitoring important lake conditions using citizen volunteers. We also thank the Department of Ecology Water Quality Grant Program for resources to set in motion the activities of the Clark County Volunteer Monitoring Program.

Other Resources:

Besides reading this manual, we encourage you to do your own research regarding volunteer monitoring, watersheds and water quality in general. Here are some useful websites:
http://www.epa.gov/volunteer/ (EPA's resources for volunteer monitors)
http://dipin.kent.edu/ (Kent State University's lake resources for volunteer monitors)
http://wa.water.usgs.gov/ (United States Geologic Survey, water resources of WA State)
http://clark.wsu.edu/volunteer/ws/index.html (Watershed Stewards, Clark County)
http://www.vancouver.wsu.edu/staff/eic/index.html (Environmental Information Center)

PROGRAM BASICS AND BACKGROUND

Volunteer monitoring is an integral part of **Clark County's Clean Water Program**. Clark County initiated the Clean Water Program in 2000 to increase protection for our streams, lakes, and groundwater. The program began in response to federal and state mandates for local government agencies to better control and clean stormwater runoff. The Clean Water Fee, which is paid by property owners in unincorporated Clark County, supports the enhanced levels of service required to accomplish these goals (Clean Water Program Annual Report, 2001 summary).

One of the first requirements for protecting or improving water quality is to have a solid foundation of standards, facilities, and programs in place. Since the Clean Water Program began, Clark County has focused on building that foundation by:

- improving stormwater and water quality facilities
- upgrading the standards that protect our water quality
- enhancing inspection, maintenance, monitoring, and education programs
- enhancing enforcement of stormwater regulations

Step by step, the Clean Water Program is building the kind of comprehensive monitoring program that will support efforts to:

- identify water quality problems (and sources of problems)
- document existing health of our lakes and streams and track long term changes
- plan appropriate projects to improve water quality
- demonstrate compliance with the county's National Pollutant Discharge Elimination System (NPDES) permit for the stormwater system

Volunteer-collected data supports the monitoring objectives of the Clean Water Program. Data collected from lakes provides baseline information about lake conditions, helps track changes over time, and provides additional information about the character of Clark County's water resources. Several years of sampling and monitoring will be necessary before water quality trends can be detected. At present, the health of lakes varies according to the amount of human disturbance in its watershed. Some are quite pristine, while others are severely degraded.

VOLUNTEER PROGRAM GOALS

Volunteer collected lake data is used for a variety of purposes in the county's water resources program:

1. Many of the methods used by volunteer monitors provide data that describes current lake condition, or the current "health" of a lake. Accelerated eutrophication, the term used to describe the rapid aging of a lake, is a primary concern of scientists, resource managers, and lake users. Eutrophication can be accelerated when pollution enters a lake from disturbances in the watershed, or the area that drains into the lake. General symptoms of eutrophication include increased algal growth from nutrient enrichment, increased rooted aquatic plant growth from

nutrient and sediment enrichment, and lower dissolved oxygen concentrations in all or parts of the lake from the decomposition of plant matter. Each of these symptoms can limit the use of the lake by humans and by wildlife.

2. Estimate irregularity in lake data throughout the lake and in different seasons.
3. Screen for potential problems or areas needing further study.
4. Report information on a regular and timely basis to fellow volunteers, county resource planners, other agencies and organizations, and the general public.
5. Facilitate public involvement and education in lake monitoring and watershed stewardship.

WHAT KIND OF MONITORING DO WE DO?

The heart of Clark County's volunteer monitoring is our **ambient monitoring** program. Volunteers are organized into small teams, under team leaders, which are assigned to a lake site or other monitoring task. Teams sample the following parameters of lake condition:

Table 1. Parameters used to describe lake condition.

Biological	Chemical	Physical
Algal density and type	Phosphorus, inorganic and total	Temperature, pH, conductivity
Chlorophyll-a	Nitrogen, inorganic and total	Dissolved oxygen
Fecal bacteria		Turbidity
		Secchi depth

WHAT HAPPENS TO THE DATA?

Volunteers enter lake data to customized field sheets which are stored at Clark County Public Works Water Resources (Water Resources) and can be viewed upon request. The data is then entered into a relational database, along with the data from other Clean Water Program projects, and includes not only monitoring results, but also information about data quality, sampling sites, samplers and their training levels, and links to our geographic information system. Annual summaries of lake health are prepared by county staff.

The main purpose of any volunteer project report is to communicate the data collected in an objective manner to the local citizens, planners, and elected officials charged with making decisions about our waterways and watersheds. Prospective users of volunteer-collected data include State water quality analysts, planners, fisheries biologists, agricultural agencies, and parks and recreation staffs; local government planning and zoning agencies; university researchers; and Federal agencies such as the U.S. Geological Survey, U.S. Fish and Wildlife Service, U.S. EPA, and U.S. Department of Agriculture. Water Resources is committed to making the environmental data available on its website.

WHO RUNS THE PROGRAM? STRUCTURE AND GOVERNANCE

Clark County volunteer monitoring includes the efforts of citizens, the Clark County Watershed Stewards, and participating civic groups. The county's Water Resources Section manages the program. Ultimate accountability for this program is to the Board of County Commissioners and to the citizens of Clark County.

Water Resources Section staff essentially guide the direction of the program to support ongoing Clean Water Program goals. But the volunteers can influence the location of monitoring locations and project affiliation through particular interests, like salmon habitat restoration, or in geographic areas, like a specific watershed. Water Resources staff works closely with other local and state agency representatives to evaluate existing data and coordinate future monitoring efforts. The volunteer monitoring program is one of the tools used by managers to meet monitoring objectives.

PROJECT STAFF

Clark County volunteer monitoring is managed by the Clark County Department of Public Works, Water Resource Section. We report to the County's Water Resource Section Manager and the Director of the Public Works Department.

Jason Wolf is a technician for Clark County and is the volunteer coordinator for various water quality monitoring projects. He has a degree from Portland State University and has experience with environmental education, water quality monitoring, biological surveys, public outreach, and volunteer coordination.

Ron Wierenga began working as a staff scientist for the county's Water Resources Section in April 2002. Ron has BS and MS degrees in Environmental Science from Washington State University. Ron is active in the development of both Water Resources and volunteer monitoring projects and in data management and analysis.

Jeff Schnabel has been working with Clark County since 1997. Jeff has a BS degree in biology from Whitman College and an MS degree in Environmental Science from Washington State University. Jeff has been active in the county's Lacamas Lake Restoration Program and is the project manager for several of the county's monitoring projects.

GENERAL OVERVIW OF VOLUNTEER ACTIVITIES BY PARAMETER

WHAT, WHEN, AND WHY WE MONITOR

During monitoring events volunteers borrow field kits and receive necessary forms from the county office. Over the course of the summer, volunteers monitor the following parameters of lake condition:

Table 2. Indicators of lake condition.

Type of Parameter	Indicator	Why?	Desired Level or Range
Biological	Algae type and abundance	Identifying and counting algae gives an indication of 1) whether polluted water or clean water algae are present, 2) whether toxin producing or bloom forming algae are present, and 3) how much of each major algal type is present.	Large diversity of algae species, especially those indicating clean water; low abundance of bloom forming or toxin producing algae.
Biological	Chlorophyll-a	Chlorophyll-a is a pigment used by algae for photosynthesis. Its concentration indicates how much algae is present.	Varies by lake type but people desire lakes with few algae, generally concentrations below 10 μg/L.
Biological	Fecal coliform	The relative abundance of fecal coliform found in a water sample serves as a warning for the likely presence of other, more dangerous pathogens in the water.	Less than 200 cfu/100mL in a water sample.
Physical	Secchi Depth	Secchi depth gives an indication of light penetration relative to the water's surface.	Varies by lake type but people desire clear lakes with good visibility, generally greater than 1.5-2 meters.
Physical	Turbidity	The amount of particles in the water affects light penetration. Turbidity provides a more sensitive indicator of water clarity than Secchi depth.	Less than 5 NTU above background conditions.
Physical	Dissolved oxygen	Oxygen is essential for aquatic life and can dictate which species are present in lakes.	Varies by lake type and by species present but generally greater than 85% oxygen saturation; do not want oxygen depletion near the lake bottom.

Type of Parameter	Indicator	Why?	Desired Level or Range
Physical	Water temperature	Water temperature regulates many metabolic and chemical processes, including algal growth.	Varies by lake type but generally below 20°C.
Physical	pH	Lakes are neither excessively acidic nor alkaline.	pH between 6.5 and 8.5
Chemical	Phosphorus	Phosphorus availability typically limits algal growth and is a good indicator of the potential for algal blooms.	Total phosphorus should be below the EPA criteria of 20-25μg/L.
Chemical	Nitrogen	Nitrogen availability can also limit algal growth.	Varies by lake.

Clark County Volunteer Monitoring Program
Lake Monitoring Manual

A word about our volunteer monitoring manual:

Background information for various lake parameters and specific monitoring tasks from the *EPA's Volunteer Lake Monitoring Manual* are presented in the following sections (Publication Number EPA440-4-91-002 available online at http://www.epa.gov/owow/monitoring/lakevm.html).

Some of the tasks were modified by county staff to reflect the equipment available to volunteers from the county's monitoring resource center. Several sections of the original EPA manual were removed to reduce the volume of this manual. Specifically, *Chapter 2: Focusing on a Lake Condition and Chapter 7: Presenting Monitoring Results* were removed but are very useful sections of the EPA manual that can be acquired from county staff our downloaded via the Web from the EPA's website.

WHERE TO SAMPLE

Where to Sample on the Water Surface

A lake and its water quality are not uniform from shore to shore or from surface to bottom. The shape of a lake's shore and bottom, exposure to winds, incoming streams, watershed development, and human activity can greatly influence the conditions found at any one location in the lake.

The majority of citizen monitoring programs are designed to measure average conditions in the lake's *pelagic* (deep, open water) *zone.* For these programs, the number and location of sampling sites are primarily influenced by the size and shape of the lake basin.

In most cases, a site over the *deepest section* of the lake best represents average conditions. In natural lakes that are circular in shape, the deepest section is usually near the middle. In reservoirs, the deepest section is usually near the dam.

Many lakes, however, possess significant arms or bays. In this instance, it is often useful to sample the deepest section in each individual arm or bay. In many cases, monitors will find a significant difference between sites, especially if one arm of the lake is more populated.

Some monitoring programs, on the other hand, are designed to characterize the condition at its worst location. For these types of programs, certain known problem areas may be targeted for sampling. For example, a particular bay may be monitored because it "collects" algae and other materials because of prevailing winds.

More often, however, "worst area" sampling is designed to monitor how sources of nutrient pollution affect water quality and algal growth. Examples of potential sources of nutrient pollution include farms, residential developments, and sewage outfalls. This monitoring can provide evidence that specific watershed management efforts are needed to manage problematic lake conditions.

The number and location of sampling sites can also be influenced by the basic goal of the program. A program managed primarily for public education, for example, may wish to include stations for various non -scientific reasons such as their proximity to residential neighborhoods or convenience of access. Such a program may even include additional stations in a lake so more volunteers can participate in monitoring.

Sample site selection should be consistent within a program in order to get results worthy of lake-to-lake comparison. For example, if the deepest part of the lake is chosen as the location for sampling, all the lakes in the program should then be sampled at the deepest site.

To select the location of a sampling site, the manager must possess some preliminary information about the lake including:

- a bathymetric (depth contour) map (or general knowledge of the location of maximum depth so that soundings can be taken in the field and a suitable sampling location identified);
- a watershed map with the lake's major inflows and outflows;
- a historical summary of water quality including the location of previous sampling sites and documentation of any lake problems (algal blooms, weed growth, fish kills);
- updates of any current activities in the watershed that may affect sampling results (point sources such as sewage plant or storm drain outfalls and nonpoint sources such as agricultural, urban, logging, and construction areas); and
- updates of any current lake activities that may affect sampling results, including dredging, water level drawdowns, and chemical applications. It is important to be aware of who manages the lake currently and how many jurisdictions are covered by the lake.

All this information will influence the selection of the sampling site. It is also important for interpreting the results of data collection efforts.

In the field, county staff and the volunteers should work together to identify and locate the proper sampling site location. Once identified, the site should be clearly marked on a lake map. The task of locating the site can be practiced by the volunteer under the supervision of county staff.

For shoreline or near-shore stations, finding the site will probably not be a problem. Many programs, however, will require volunteers to sample over the deepest portion of the lake. This usually means the monitoring site will be somewhere in the middle of the waterbody. For volunteers to return consistently to the same sampling site location, they must use a method.

Two simple ways to find the site are by:

- locating the site by using landmarks visible on the shore; or
- setting a permanent marker buoy at the sampling location.

Shoreline Landmark Method

On land, volunteers know where they are located by finding familiar landmarks. The same process can be used on water, except that the landmarks are located on the shoreline. On an initial training trip, the volunteer and county staff must designate an "official" site location.

Once securely anchored at the site, the volunteer should pick out two permanent landmarks on shore (a dwelling, tall tree, large rocks) that align one behind the other. This alignment forms an imaginary bearing line through the objects to the site.

Then, at about a 90 degree angle, two more aligning landmarks should be identified. These landmarks then form a second bearing line to the sampling site. Volunteers should mark these landmarks and bearing lines on their lake map for future reference. They should also practice finding the site location with county staff.

To further verify that volunteers have found the proper sampling site, county staff may also require that they perform a depth check using the anchor rope, a weighted calibrated sounding line, or an electric "fish-finder" apparatus that indicates bottom depth.

Marker Buoy Method

If the lake is small and protected from strong winds and waves, a marker buoy may be the simplest way to designate a sample site location. In many public lakes, however, it is illegal to set out buoys without proper permits. The rules and regulations regarding buoys should be checked before any placement.

There is a risk that a marker buoy will be moved by winds, waves, and /or lake users. Thus, volunteers should also be trained to verify that the buoy is in the proper location using the shoreline landmark method before starting the sampling procedure. This training will be useful if the buoy is lost or needs to be repositioned.

Where to Sample in the Water Column

Free-floating algae grow and reproduce in the *photic zone*. This zone constitutes the upper portion of the water column where sunlight penetrates and stimulates photosynthesis in algal cells. In programs designed to measure the algal condition of a lake, water samples are taken from the photic zone and analyzed in a laboratory for their chlorophyll *a* and total phosphorus content.

Where these samples are taken in the photic zone is another important decision that must be made by staff and volunteers. There are two basic choices for water sampling in the photic zone. Volunteers can collect:

- a point sample taken at a specific depth; or
- an integrated sample from a range of depths.

Point Sampling

Point sampling refers to the collection of a water sample from a specific depth in the water column. Also known as *grab sampling*, it is the method most often used in monitoring programs.

When measuring the algal condition parameters, a sample is usually taken at a selected depth between one-half and two meters. (Water samples are generally not collected directly at the surface because floating substances such as pollen and gasoline residue can contaminate them.)

If a depth of one-half meter is selected, volunteers can collect the sample by simply submerging the sample bottle to about elbow depth. For deeper point sampling, some type of water sampler instrument must be used.

A *Van Dorn* water sampler is commonly used to collect water at a specific depth. These devices are cylindrical tubes with stoppers at each end. After the sampler has been lowered to the desired depth (marked on the lowering line), the volunteer slides a weight (called a *messenger*) down the line.

When the messenger reaches the sampler, it hits a trigger mechanism and the two stoppers snap shut, trapping the sample of water from that depth. The sampler is then hauled back into the boat and the sample water poured into a container.

The goals of the monitoring program and how the water quality data will be used will help staff and volunteers determine where a point sample should be collected. <u>A depth of one meter</u> is selected many times as a representative depth of photic zone conditions for chlorophyll *a* and nutrient analyses.

If a water sampler is used, other depths in the water column also can be easily sampled by the volunteer. Total phosphorus is an especially interesting parameter to monitor at different points in the water column, in addition to the upper layer photic zone.

Phosphorus is released from bottom sediments under anaerobic (no oxygen) conditions. If the lake is strongly stratified in the summer, and wind energy does not mix the water column, the bottom-released phosphorus cannot reach the photic zone and stimulate increased algal growth. In some lakes, however, summer stratification occasionally breaks down and the bottom phosphorus does reach the surface waters, causing sudden algal blooms.

This *internal* loading of phosphorus is often important when analyzing the algal condition of productive lakes. For this reason, volunteers should consider collecting point samples from the bottom and middle of the water column for total phosphorus analysis, as well as in the photic zone.

Integrated Sampling

An integrated sample combines water from a range of depths in the water column. It is essentially a mixture of point samples designed to represent more of the photic zone than a single sample. The simplest way for volunteers to collect an integrated sample is to use a hose and bucket.

Basically, a measured length of hose is weighted on one end and then lowered into the lake. While the hose descends, it collects a vertical column of water. By plugging the surface end and then bringing the lowered end to the surface with a line, an intact column of water can then be emptied into a bucket and a sample drawn for laboratory analysis.

A basic drawback is that this method can not be easily standardized. Each volunteer will develop his/her own variation of this sample collection technique. Losing a portion of the sample while bringing up the hose may also be a problem for some volunteers. For these reasons, <u>many monitoring programs rely on point sampling</u> for measuring the algal conditions of lakes.

FREQUENCY OF SAMPLING

Many lake parameters change rapidly during the course of a day, week, month, and year. Water temperatures and lake stratification, nutrient levels, and water clarity are variable, or irregular. There is usually a change in the quantity and species of algae occurring in a lake throughout the year. Often algal density increases in the spring and early summer as water temperatures increase and nutrients become available in the well-lit upper layer as a result of spring overturn.

Most lakes over 20 feet deep stratify during the summer into a warm, lighted upper layer (epilimnion) and a cold, dark lower layer (hypolimnion). When summer arrives and the lake stratifies, the algae population may change as the supply of nutrients in the upper layer becomes depleted and/or microscopic animals (zooplankton) graze on the population. After the summer, water temperatures cool down and lakes re-mix which can once again bring fresh nutrients to the well-lit upper zone and stimulate increased algal growth.

A variety of other factors can also affect algal habitat and growth response, especially during the summer growing season. Storms can churn the lake and cause a temporary upwelling of nutrients from the lake bottom. Phosphorus-rich runoff can escape from residential or agricultural areas after rainstorms, drain into the lake, and stimulate growth. On the other hand, chemicals or herbicides that are toxic to algae may be released to the water and cause a (planned or unplanned) population crash.

County staff and volunteers should base the decision on how often to sample on data quality criteria, costs, and other practical considerations.

Many citizen monitoring programs have found it appropriate to sample algal conditions on a two-week or bi-monthly cycle. In most cases, this time period has proven adequate to monitor changes in the algal parameters and, at the same time, fit into volunteers' participation schedules.

However, if conditions are known to change at more frequent intervals (if lake water flushes quickly through an inlet and outlet), volunteers may determine that weekly sampling is more appropriate.

More frequent sampling also improves the odds of measuring a short-term event such as an algal bloom or a sudden pulse of phosphorus input because of storm runoff or a sewage plant bypass. Expense becomes a key factor when determining sampling frequency because each sampling round will increase program costs.

Length of the Sampling Season

An ideal monitoring program runs year-round to collect the full amount of seasonal data on the lake. This regime would test the dedication of citizen volunteers to an extreme, however. A more practical sampling period for citizen monitoring is from spring overturn to the end of the summer growing season.

Spring overturn is important because it is when wind action circulates the entire volume of water. Importantly, citizens can sample the spring algal blooms that are sometimes observed as a result of increased nutrient availability and warming water temperatures.

The summer growing season corresponds with the main recreational season. It is during this time that increased algal growth is most objectionable because it can interfere with swimming, water-skiing, fishing, and other activities.

Fall overturn is another time when the water circulates and algal blooms typically occur. This season is not as important to the general public, however, because it comes at the end of the recreational season. Thus, fall algal blooms are not usually perceived as a problem. Volunteer interest also wanes as the weather turns cooler and more unpredictable. For these reasons, it is often prudent to stop monitoring at the end of summer.

MONITORING ALGAE

Algal Condition Parameters

Monitoring the algal condition in lakes is the focus of the majority of citizen volunteer monitoring programs operating today. There are three prominent reasons for this decision.

- Most citizen volunteers desire lakes that have clear water with a slight blue tinge. Deviation from this accepted standard raises public interest about water quality. In many lakes, it is the algae population that decreases clarity and colors the water.

- Parameters commonly used to measure the algal condition of a lake can be sampled easily by volunteers using basic equipment.

- Parameters that measure the algal condition form the basis for many commonly used trophic state indices, or benchmarks for amounts of algal growth. These indices provide a quantitative means of describing the level of lake aging (eutrophication). Using a trophic state index, program officials can rank lakes according to the results of the monitoring program.

Three parameters are most often used by citizen monitoring programs to measure algal conditions in lakes:

- **Secchi disk transparency**
  This parameter is a measurement of water clarity. In many lakes, a reduction of clarity occurs as the algal population grows. In these cases, a Secchi disk reading can be used as an indirect measure of algal density.

- **Chlorophyll *a***
  This parameter is a more reliable indicator of algal quantity because chlorophyll *a* is a chemical extracted directly from the algal cells present in a water sample.

- **Total phosphorus**
  This parameter is an essential plant nutrient that stimulates the growth of algae in many lakes (the more phosphorus in the lake, the more algae). By measuring phosphorus concentration, monitors can get an indication of water fertility.

Each of the three parameters, if measured by itself, will not provide a complete picture of the algal condition of a lake. Measured together, however, they can provide valuable information about the relationship between water fertility and algal growth. Volunteers are especially interested in how algal growth affects water clarity, the lake trait most noticed by the majority of lake residents and users.

Secchi Disk Transparency

First developed by Professor P.A. Secchi in 1865 for a Vatican-financed Mediterranean oceanographic expedition, the Secchi disk has since become a standard piece of equipment for lake scientists. It is simply a weighted circular disk 20 centimeters (about eight inches) in diameter with four alternating black and white sections painted on the surface.

The disk is attached to a measured line that is marked off either in meters (subdivided by tenths of meter), if using metric units, or feet (subdivided by tenths of feet or inches), if using English units.

The Secchi disk is used to measure water clarity, or how far a person can see into the water. It is lowered into the lake by the measured line until the observer loses sight of it. The disk is then raised until it reappears. The depth of the water where the disk reappears is the Secchi disk reading.

In extremely clear lakes, disk readings greater than 10 meters can be measured. On the other hand, lakes affected by large amounts of algal growth, suspended sediments, or other conditions often have readings of less than one-half meter.

In some shallow lakes, it is impossible to get a Secchi disk reading because the disk hits the bottom before vanishing from sight. This means the true Secchi disk reading is greater than the depth of the lake in that particular location.

Unfortunately, Secchi disk data are among the most abused and misinterpreted measurements in monitoring programs because people often directly equate Secchi disk readings with algal density. There are, however, many other factors found both inside and outside the lake that affect water clarity.

Inside the lake, water clarity can be reduced by:

- microscopic organisms other than algae;
- natural or unnatural dissolved materials that color or stain the water; and
- suspended sediments.

Factors outside the lake can also affect a Secchi disk reading. These outside factors can include:

- the observer's eyesight and other sources of human error;
- the angle of the sun (time of day, latitude, season of the year);
- weather conditions (cloud cover, rain); and
- water surface conditions (waves, sun glare, surface scum).

In sum, the Secchi disk should always be considered simply as an instrument to measure water clarity. Algae can play an important role in reducing clarity; however, this assumption must be proven by measuring a parameter directly associated with the algal population. For many citizen monitoring programs, this parameter is chlorophyll *a*.

Chlorophyll a

Chlorophyll *a* is the green photosynthetic pigment found in the cells of all algae. By taking a measured sample of lake water and extracting the chlorophyll *a* from the algae cells contained in that sample, monitors can get a good indication of the density of the algal population.

The chlorophyll *a* concentration cannot be considered a precise measurement of algal density, however, because the amount of chlorophyll *a* found in living cells varies among algal species. Thus, two lakes can have identical densities of algae yet have significantly different concentrations of chlorophyll *a* because they are dominated by different species.

Direct comparability, even within a single lake, is further complicated by the fact that the amount of chlorophyll *a* in an algal cell varies with light conditions. Healthy algal cells constantly try to maintain chlorophyll concentrations at a level for maximum photosynthetic efficiency. Chlorophyll in a cell usually decreases during high light conditions and increases during the night or low light conditions.

Similarly, a cell that is sinking down into the water column (away from the sun) may also produce more chlorophyll to compensate for the lower light levels found at greater depths. Changing seasons also create higher or lower light conditions according to the position of the sun which, in turn, affects chlorophyll production.

Despite these drawbacks, the ease of sampling and relatively low cost of analysis makes chlorophyll *a* an attractive parameter for characterizing the algal density in lakes, especially for volunteer monitoring programs.

Chlorophyll *a* is analyzed in a laboratory from a sample collected by a volunteer. The simplest protocol is to ship the water sample to the laboratory for analysis.

Alternatively, some citizen monitoring programs have volunteers pass a measured volume of lake water through a filtering apparatus containing a prepared filter paper disk. The filter paper lets the water pass through but retains the algae cells on its surface. The volunteer then removes the disk and places it in a special tube to be forwarded to the laboratory for chlorophyll *a* analysis.

In some instances, this procedure may produce lower than actual results for chlorophyll *a* concentrations if the filtering procedure is not followed exactly. Quality assurance considerations will determine if this method is a feasible alternative for a volunteer program.

Total Phosphorus and Other Nutrients

Phosphorus is one of several essential nutrients that algae need to grow and reproduce. In many lakes, phosphorus is in short supply. Therefore, it often serves as a limiting factor for algal growth.

Phosphorus migrates to lake water from only a few natural sources. As a result, lakes located in pristine wilderness settings rarely have problems with algal blooms. Humans, on the other hand, use and dispose of phosphorus on a daily basis. Phosphorus is found in such common items as fertilizers, foods, and laundry detergents.

Lakes with developed watersheds often receive a portion of this human-generated phosphorus through runoff, septic leachate, and other sources. This phosphorus fertilizes the water and can stimulate increased algal growth.

Algae most readily consume a form of phosphorus known as orthophosphate, the simplest form of phosphorus found in natural waters. In fact, orthophosphate is so quickly taken up by a growing algal population that it often is found only in low concentrations in lakes.

Phosphorus is found in lakes in several forms other than orthophosphate. For example, when phosphorus is absorbed by algae, it becomes organically bound to a living cell. When the cell dies, the phosphorus is still bound to particles even as it settles to the lake bottom. Once the decomposer organisms break down the cell, the phosphorus can become attached to calcium, iron, aluminum, and other ions.

Under anoxic (no oxygen) conditions, chemical reactions can release phosphorus from the sediments to the overlying waters. Spring or fall overturn may then redistribute it back to the surface where it can be taken up by another algal cell.

Phosphorus, therefore, fluctuates as environmental conditions change and plants and animals live, die, and decompose in the lake. Because the forms of phosphorus are constantly changing and recycling, it is generally most appropriate for citizen monitoring programs to measure all forms of phosphorus together. This one "umbrella" measurement is known as <u>total phosphorus</u>.

This manual describes a method that instructs the volunteer to collect a water sample, transfer it into a sample bottle that contains an acid preservative, and then ship it to a laboratory for total phosphorus analysis.

In some instances, other forms of phosphorus, such as inorganic orthophosphate, may be a parameter of interest since it is the form of phosphorus available for uptake by algae. Also, total nitrogen and inorganic nitrogen, including nitrate and ammonia, are of interest to lake managers. The ratios of various forms or types of nutrients give indications of the types of algae present or the types of nutrient pollution affecting the lake. Like total phosphorus, other nutrients are best measured in a laboratory.

Sampling Tasks for Monitoring Algae

Presented in this section are suggested procedures for sampling Secchi disk depth, chlorophyll *a,* and total phosphorus and nutrient concentrations for a citizen monitoring program.

County staff should provide volunteers with a sampling schedule and a sampling protocol sheet. In general, monitors should be instructed to conduct sampling between 10 a.m. and 3 p.m. Volunteers must understand, however, that there is flexibility in both the day and time, especially in consideration of weather conditions.

Volunteers' common sense and good judgment dictate when it is appropriate to sample. Both good and unacceptable weather conditions should be defined for volunteers during training sessions. Under no circumstances should volunteers be on the water during rain or electrical storms, high winds (white caps), or other unsafe conditions.

Know Before You Go: Guidelines for Monitoring

<u>Taking Care of YOU:</u>

- **Safety first**! Nothing is more important. Don't go out alone, and make sure somebody knows where you're going and when you expect to be back. Cell phones are handy but not always reliable. Go through the boating safety equipment checklist shown below. Before leaving shore, confirm that all needed safety equipment is on board. Boating safety is a subject that volunteers need to take seriously because they will be moving around the boat, leaning over the edge, and working with equipment. Volunteers must wear a life preserver (Type 1, 2 or 3 personal flotation device) at all times. Volunteers should educate themselves about safe boating laws.

  Confirm that the following boating safety equipment is on board the sampling boat:

  - Personal flotation device for each person. Devices must be Coast Guard-approved, readily available, and the proper size.
  - First aid kit.
  - Other equipment that may be required by State and local boating laws. For example, boats may be required to carry fire extinguishers and sound-producing devices. Also, the boat must be registered according to State and local laws.

- **Fatigue**: Note your energy level and those of your teammates. Know when to quit.
- **Water samples**: Volunteers should wear clean vinyl gloves and should not smoke. They must always be aware that the phosphorus sample bottle contains an acid that preserves the sample during transport to the laboratory. This acid must be treated cautiously because it can burn skin or clothing if spilled or mishandled. Volunteers should also not breathe the vapors from the opened bottle.
- **Hazardous materials**: The most dangerous material we use is acid, but you may find other hazardous materials at your sites – broken glass, needles, human/animal wastes, etc.
- **Weather gear**: Be prepared for rain, wind, and cold. For cold, bring a thermos or a St. Bernard, plus extra layers of clothing, rain gear, and a warm hat (remember – you lose 75% of your body

heat through your head). For heat, bring a hat, sunblock, and plenty to drink. For brush and biting insects, long pants and sleeves are good.

- **Rain**: If it begins to rain heavily, thunder, lightning, or hail, GET OFF THE LAKE and into your car. If it seems to be a passing storm, try waiting it out and then returning to the site. Note on your field form the time you left and returned, and about how much rain fell, keep an eye on water levels if it has been raining anywhere in the watershed.

Review the Monitoring Sequence:

- Confirm sampling day and weather conditions. Check the sampling date on the program sampling schedule. Check the current and forecasted weather and decide if the conditions allow for safe sampling. The volunteer should also be instructed to confirm this decision after personally inspecting lake conditions prior to launching the boat and beginning the sampling trip.
- Inventory the field kits for completeness before taking them out. Before leaving shore, volunteers must make sure that they have all the needed sampling equipment and supplies on board the boat. Confirm that the following sampling equipment and supplies are on board the sampling boat:
    - Anchor (with a measured line if a depth check is required). Two anchors are helpful on windy days, one off the bow and the other off the stern
    - Weighted sounding line for measuring depth.
    - Air thermometer
    - YSI DO/Temp meter
    - YSI pH meter
    - Secchi disk with a measured line
    - Water sampler with messenger
    - Water sample containers
    - Ice cooler (with a closable lid) with frozen ice packs
    - Datasheet, clipboard, and pencils
    - Map of lake with sampling site and landmarks marked
    - Sampling protocol sheet
- Perform dissolved oxygen, water temperature, and pH profiles first, followed by Secchi depth and lastly collect water samples.
- Turn in your samples, datasheets, and equipment to county staff or to the laboratory.

The Steps for Monitoring Algae

Step 1: Position your boat at the designated sample site.

Volunteers must locate the sample site on the water. Whether or not a marking buoy is used, the position should be verified using the shoreline landmark method.

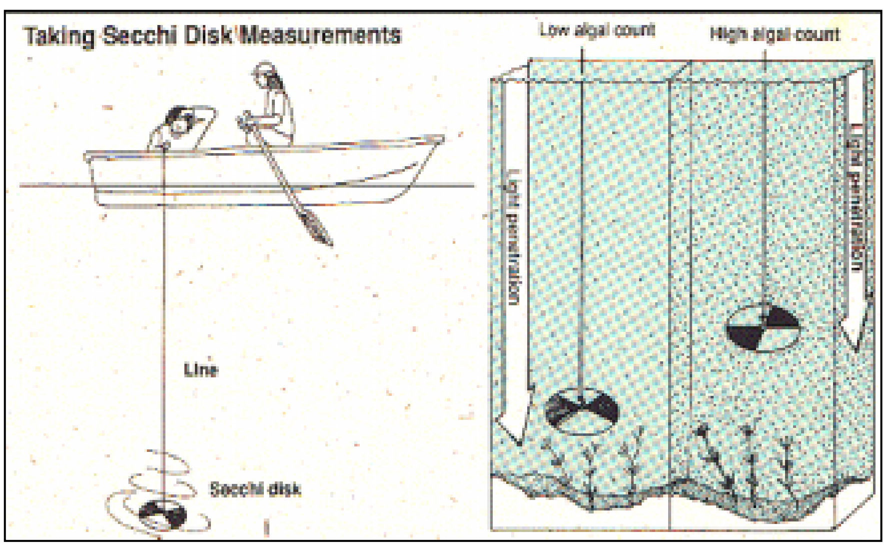
Once the site is located, volunteers can anchor the boat. Repositioning the anchor once it is dropped should be discouraged, especially in shallow lakes, because it can stir up sediments from the lake bottom. Increasing sediment turbidity may alter data results.

After anchoring, volunteers should allow the boat to stabilize. Then a depth check can be done.

Step 2: Complete the observations portion of the sampling form.

- Record the name of the lake and site, the date, the time of sampling, and the names of volunteers doing the sampling.
- Record water condition observations at the site including water color, suspended sediment and algae, aquatic plants, waterfowl activity, and odor.
- Record weather conditions on the form including the amount of cloud cover (when taking the Secchi disk reading), the approximate air temperature, and the wind speed and direction, and water surface conditions. Wind and surface waves should be described using the terms “light”, “medium”, and “heavy”. Indicate any unusual weather conditions that may have occurred in the past week including storms, high winds, and temperature extremes.
- Record any other factors or conditions that make the sampling trip unusual or that may potentially influence sample results. For example, report any chemical, mechanical, or biological control of algae or aquatic weeds that may have been done recently on the lake.

Step 3: Measure the Secchi disk depth.



The Secchi disk is used to measure the depth that a person can see into the water (clarity). A Secchi disk reading is a personal measurement; it involves only two pieces of equipment, the disc and the person's eyesight.

Figure 1. How Secchi Depth is measured, From A Citizen Guide to Water Quality Monitoring, Washington State Department of Ecology, 1991.

Step 3: Measure the Secchi disk depth (continued).

1. Check to make sure that the Secchi disk is securely attached to the measured line.
2. Remove sunglasses before taking the measurement.
3. Lean over the shady side of the boat and lower the Secchi disk into the water, keeping your back toward the sun to block glare.
4. Continue to lower the disk until it just disappears from view. Lower the disk another one third of a meter and then slowly raise the disc until it just reappears. Continue to move the disk up and down until the exact vanishing/reappearing point is found.
5. Place your fingers on the line at the point where the line enters the water. This is the point the measurement will be read.
6. Slowly pull the disk out of the water and record the measurement based on the location of your finger on the line.
7. Repeat the procedure as a quality control check; an average of the two readings should be recorded on the sampling form.

Step 4: Collect a water sample for chlorophyll a, nutrients, and turbidity.

1. Make sure the sample bottles are labeled with:
    a. the parameter to be analyzed
    b. the date, time, and the sample lake, location, and depth the sample is collected from.
2. Check to make sure that the water sampler is securely attached to the measured line (marked in meters like the Secchi disk line).
3. Set the sampler by hooking the wire loops on the end caps to the trigger mechanism. Hook the upper cap first, then the lower. Be careful not to trigger the sampler and get hands or fingers caught in the sampler.
4. Lower the sampler gently into the water to the desired depth marked on the line (rough treatment can trigger the closing mechanism prematurely).
5. Slide the messenger down the line to close the stoppers.
6. Gently haul the sampler to the surface, and then release some of the sample water through the nozzle. The sampler must be vented by either opening the upper nozzle or by squeezing one of the rubber end caps.

Figure 2. Volunteer with the water sampler after a sample has been collected.

7. Confirm that there is acid present in the bottom of the nutrient bottle by visual inspection. Move the sample bottle into position and remove the cap, being careful not to spill the acid contents or breathe in the vapors. Gently shake the sampler with the sample water to re-suspend any settled material. Gently pour the sample water into the bottle until the liquid reaches the fill line. Cap the sample bottle and place it into the shipment container with the frozen ice packs and close the lid so sunlight cannot reach it. Repeat the procedure with the chlorophyll a and algae sample bottles and a small glass turbidity vial.

Figure 3. Filling sample bottles out of a Van Dorn sampler.

8. Store the container in the ice cooler away from the light. The water samples will be shipped to the laboratory for analysis.

Step 5: Measure the turbidity of the water sample.

1. On the datasheed, record the last calibration date marked on the lid of the meter.
2. Check the calibration of the meter:
    a. Take either the 5 or 50 NTU Gelex reference vial out of the box holding it by the cap or upper part only.
    b. Clean the critical measuring are with a lint-free tissue or cloth.
    c. Place this vial in the meter's chamber, aligning the white diamond on the vial with the plastic notch in the chamber collar.
    d. On the datasheet record the # of NTUs listed on the top of the Gelex vial.
    e. Press "Read" on the meter and record the reading to the nearest 0.01 NTU.
3. Gently invert the glass sample vial that was filled in previous steps.
4. Dry and clean the vial with a lint-free tissue or cloth.
5. Insert the vial in the chamber, aligning the diamond on the vial's side with the notch on the well's collar ring.
6. Press the "Read" key and record the final reading on the datasheet.

Step 6: Cleanup and shipment of samples and forms.

1. Clean the sampling and laboratory equipment for the next sampling trip. The Secchi disk and water sampler should be rinsed off with fresh tap water and the sampling container rinsed with distilled water.
2. Pack and forward the sample cooler with the samples to the laboratory as soon as possible. In addition, the sampling form with the Secchi disk measurement and sampling observations must be sent to county staff. Check over all field sheets for completeness and clarity before turning them in.
3. Turn in your equipment on time. Leave equipment out to dry if you're storing it at home for a period.
4. Check in your field kits with county staff. Leave notes for staff if equipment needs maintenance, replacement, or calibration.
5. Notify the coordinator of volunteer hours, if applicable.

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MONITORING OTHER INDICATORS OF LAKE CONDITION

Depending on the specific project plans county staff may direct volunteers to monitor other parameters that are indicators of lake condition. In addition, volunteers working on their own projects may have goals that include the assessment of additional monitoring parameters. The sections below provide guidance on two additional parameters, bacteria and sediment.

Monitoring Bacteria at Bathing Beaches

A wide variety of disease-causing organisms can be transmitted to humans at bathing beaches. Sources of pathogens include sewage, runoff from animal or wildfowl areas, and even swimmers themselves.

Because of the risk of waterborne disease, it is good public health practice to test beaches periodically during the swimming season. The Clark County Health Department often monitors for the presence of one or more indicator organisms as part of a regular sampling program. The relative abundance of an indicator organism found in a water sample serves as a warning for the likely presence of other, more dangerous pathogens in the water.

The indicator organisms most often used to indicate sanitary conditions at bathing beaches include fecal coliform, E. coli, and enterococcus bacteria. Coliforms belong to the enteric bacteria group, Enterobacteriaceae, which consists of various species found in the environment and in the intestinal tract of warm-blooded animals. Fecal coliform are the part of the coliform group that is derived from the feces of warm-blooded animals. The fecal test differentiates between coliforms of fecal origin and those from other sources.

E. coli and Enterococcus are a subset of the fecal coliform group. Like fecal coliforms, they, too, indicate fecal contamination by warm-blooded animals. They are useful because they are found only in certain animals. Examination of the ratio of fecal coliform to enterococcus can indicate whether the bacterial pollution is from humans or animals.

Most public health officials recommend bi-weekly testing of swimming beach areas. Sampling should occur at one or more sampling sites in water three to four feet deep. A sterilized sampling bottle should be prepared by the laboratory.

Sampling for bacteria at beaches should be conducted under the auspices of the Clark County Health Department. Analysis should be done at a certified laboratory. If a problem is found, program officials should notify health authorities for follow-up testing and mitigation activities.

The Steps for Monitoring Bacteria

See the previous section, “Sampling Tasks for Monitoring Algae”, for general sampling guidelines on pp 20-21.

Step 1: Locate sampling sites on the beach

Locate the sample site on the beach if a designated sample location is either marked or has been described in the project plan. If the monitoring is a new effort, volunteers must determine appropriate locations to collect samples. The number of sites needed will vary with the length and configuration of the beach. One site is generally adequate if the beach shoreline is 300 linear feet or less. If the shoreline is between 300 and 700 linear feet, a minimum of two sites is recommended. A beach shoreline greater than 700 feet requires three or more sample sites.

Step 2: Complete the observations portion of the sampling form.

- Record the name of the lake and site, the date, the time of sampling, and the names of volunteers doing the sampling.
- Record water condition observations at the site including water color, suspended sediment and algae, aquatic plants, waterfowl activity, and odor.
- Record weather conditions on the form including the amount of cloud cover, the approximate air temperature, and the wind speed and direction, and water surface conditions. Wind and surface waves should be described using the terms “light”, “medium”, and “heavy”. Indicate any unusual weather conditions that may have occurred in the past week including storms, high winds, and temperature extremes.
- Record any other factors or conditions that make the sampling trip unusual or that may potentially influence sample results. For example, report any chemical, mechanical, or biological control of algae or aquatic weeds that may have been done recently on the lake.

Step 3: Collecting the bacteria sample.

1. Remove the cap from a sterile collection bottle without touching the inside of the cap or the inside of the bottle.
2. Grip the bottle at the base and plunge it in a downward motion into the water to a depth of 12 to 18 inches. (Note: Some commercial labs provide bottles with a sodium thiosulfate tablet that is unnecessary for lake samples; discard the tablet).
3. Using a forward sweeping motion (so water is not washed over the hand into the bottle), invert the bottle and bring it to the surface.
4. Empty it slightly to leave approximately one inch of air at the top.
5. Re-cap the container, then label and store it on ice in a sample cooler at a temperature between 39° and 45° F.
6. Transport the bottle to the laboratory as soon as possible after sampling.

Monitoring Suspended Sediment

Some of the silt and organic matter that enters a lake does not settle to the lake bottom. Instead it remains suspended in the water. These suspended solids decrease water clarity and can affect the suitability of the lake habitat for some species. In addition, solids often carry in significant amounts of nutrients that fertilize rooted aquatic plants and algae.

Total solids is a term used to describe all the matter suspended or dissolved in water. *Total suspended solids (TSS)* is that portion of the total solids that are retained on filter paper after a sample of water is passed through.

Citizens can monitor the suspended sediment condition by measuring two parameters: water clarity using a Secchi disk; and total suspended solids.

The Secchi disk is an instrument that measures water clarity. The reader is referred to page 23 of this manual for a thorough explanation of its use in lake monitoring.

The concentration of TSS in a water sample is analyzed in a laboratory. Procedures involve the use of a filtering apparatus, a special drying oven that can maintain a constant temperature between 103° and 105° F and a sensitive analytical balance capable of weighing material to 0.1 milligrams.

In most cases, volunteers will take a grab sample, as directed in the previous section, to be analyzed at a laboratory for TSS. County staff will make clear the instructions for filling appropriate bottles in the project plan. The sample must be kept cold and shipped to the laboratory as soon as possible after collection to minimize microbiological decomposition of solids.

This monitoring is particularly useful for analyzing trends in suspended material after storm events. For this reason, county staff may wish to instruct volunteers to sample on a two-week schedule for baseline purposes and then to conduct additional sampling after storms.

Monitoring Sedimentation

Sedimentation problems occur when erosion is taking place in the watershed. Surface runoff washes sand and silt into the lake where it settles to the bottom and creates shallow areas that interfere with lake use and enjoyment. In addition, sediments often carry significant amounts of nutrients that can fertilize rooted aquatic plants and algae.

Citizens can characterize the build-up of sediments by measuring water depth and the depth of unconsolidated (soft bottom) sediments in key areas (mouths of tributary streams or near an eroding shoreline). In this manner, a historical record of sedimentation can be developed.

To measure sediment, set up a transect line and sample at specified intervals along it. A basic procedure involves the use of two dowels (probes) about one inch in diameter and long enough to remain above the surface at the deepest point of measurement. Securely attached to the bottom of one probe is a nine-inch plate (a pie pan works well). Both probes are marked in meters and tenths of meters.

Working along a transect line, volunteers can:

- locate the sample site along a transect.
- measure and record the depth of the water from the surface to the top of the sediments using the probe with the plate on the end.
- push the other probe into the sediments until it becomes hard to push, measure and record the depth. The difference between the two depths is the thickness of the unconsolidated sediments.

The number of transects and the location of sites along those transects will be decided by the project plan. By participating in a sediment recording program, the volunteers will gain appreciation that erosion and sedimentation are important lake management problems.

References

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MONITORING PHYSICAL AND CHEMICAL PROFILES

Oxygen and Water Temperature Profiles

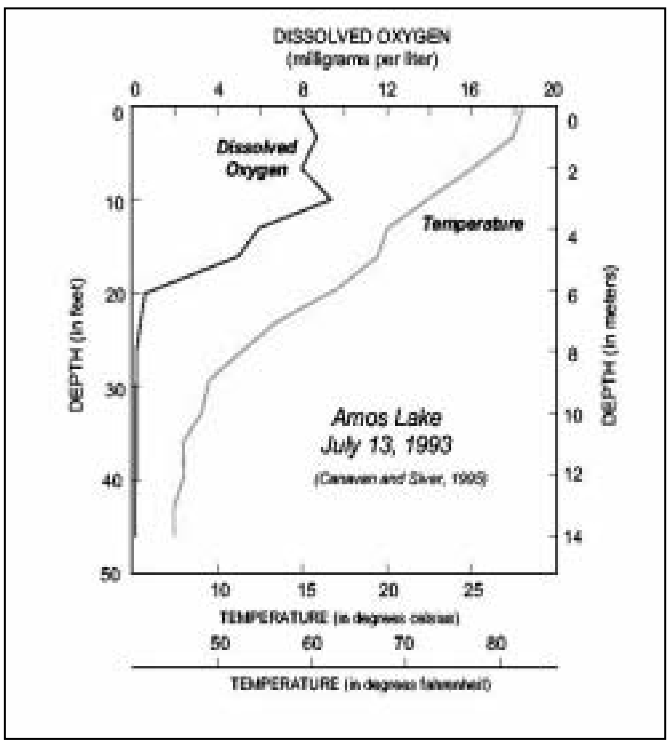
The amount of dissolved oxygen in the water is an important indicator of overall lake health. When oxygen is reduced, organisms are stressed. When oxygen is absent, all oxygen-breathing life forms must either move to an oxygenated zone or die.

There are also many chemical reactions that occur depending on whether or not oxygen is in the water. For example, an essential plant nutrient, phosphorus, can be released from bottom sediments when oxygen is reduced in the lower layer of a lake.

Dissolved oxygen conditions are best characterized by measuring:

- the dissolved oxygen profile (measurements from the surface to the bottom at set intervals); and
- the temperature profile (at the same intervals).

Dissolved Oxygen Profile



When characterizing the oxygen condition in a lake, it is important to know how oxygen concentrations differ from the surface to the bottom. In lakes that have a problem with low dissolved oxygen, it is not unusual to measure high dissolved oxygen levels at the surface during the day because algae in the photic zone are photosynthesizing and producing oxygen. At night, these same algae respire and consume oxygen.

Near the bottom, however, there may be little or no oxygen because decomposers are using it while breaking down the "rain" of organic matter (dead algae cells, zooplankton, fish) falling from above.

A profile of oxygen measurements taken from top to bottom may provide insight on the relative populations of oxygen-producing plants and bottom -dwelling decomposers.

Figure 4. Example dissolved oxygen and water temperature profile from a deep lake.

Temperature Profile

Water temperature plays an important role in determining the amount of oxygen found in the lake. Oxygen is more soluble in cold than warm water. Most lakes over 20 feet deep stratify during the summer into a warm, lighted upper layer (epilimnion) and a cold, dark lower layer (hypolimnion). Thus, the cold lower layer can potentially hold more oxygen than the warmer upper layer.

Usually these layers do not mix; thus, the bottom layer is cut off from atmospheric oxygen and oxygen-producing plants. Consequently, bottom oxygen can become depleted if there is an active population of decomposers in the bottom sediments. For these reasons, it is important to define the thermal layers in a lake when characterizing dissolved oxygen conditions.

Other Profile Parameters

pH and Conductivity Profiles

pH and conductivity are important indicators of water chemistry. This data can be used to assess vertical differences in overall chemistry, mixing characteristics, and the level of algal growth. The measurement of pH and conductivity is used in conjunction with nutrient data to describe gradients in the lake and how they may relate to algal growth.

The pH of water has an important influence on chemical reactions and chemical availability. pH often changes with rapid algal growth, increasing to levels higher than the neutral level of about 7. Conversely, effects of pollution from the atmosphere known as acid deposition or acid rain can lower the pH of the water.

Sampling Tasks for Monitoring Physical and Chemical Profiles

Refer to the section “Monitoring for Algae” (pp. 10-15) for descriptions of when and where to sample. Typically, profiles are measured at the same frequency and locations of the other lake condition parameters.

Profile measurements should begin with spring overturn in stratified lakes. At that time, both temperature and oxygen concentration are uniform from top to bottom in most lakes. Sampling should continue throughout the summer season. It may be even useful to extend the program to fall overturn.

To track the progress of oxygen depletion in the lower layer, sampling should be conducted every two weeks. In some cases, it may be useful to build some flexibility into the program and encourage volunteers to gather profile data after large, windy storms. This effort will document whether lake stratification breaks down under storm or high wind conditions.

Additionally, if there is a large crop of aquatic weeds or algae, county staff may wish to have volunteers sample the oxygen concentration in the photic zone in the early morning to evaluate the impact of nighttime respiration. There are two methods of measuring dissolved oxygen in a lake. Volunteers can use a dissolved oxygen field kit, or a submersible oxygen meter.

Field kits are available from many manufacturers. All kits basically require that volunteers take a water sample and analyze dissolved oxygen using a titrimetric procedure. The sample must be analyzed immediately after collection.

To get meaningful results, volunteers must observe strict sample handling protocol. Contact with the air, agitation, exposure to strong sunlight, and temperature and pressure changes will affect the oxygen content of a sample.

These factors, plus the fact that several dissolved oxygen measurements are needed to make up a profile, makes the use of field kits generally unsuitable for volunteer programs that are monitoring the dissolved oxygen profile in lakes. If the goal of the program, however, is to simply sample oxygen in the photic zone and not create a full water column profile, a dissolved oxygen kit may be an attractive and less expensive alternative.

The most convenient method for taking both oxygen and temperature profiles, however, is to use a portable oxygen meter that incorporates a thermistor. The meter displays a dissolved oxygen readout based on the rate of diffusion of molecular oxygen across a membrane. The thermistor component of the instrument provides a temperature readout.

Each meter manufacturer provides detailed instructions on sampling protocol and how and when to calibrate the meter to obtain guaranteed precision and accuracy. Calibration should be done by county staff at the manufacturer-recommended intervals. This means the instrument will have to be transported between the volunteer and staff between those intervals.

The meter used for temperature and oxygen measurements also measures conductivity. A separate pH meter may be used to do the pH profile.

The Steps for Monitoring Physical and Chemical Profiles

Suggested procedures for measuring profiles of a lake are described in this section. Refer to pages 10-15 for steps on locating sample sites and recording basic site conditions.

Step 1: Measure the depth of the site.

Using a weighted calibrated sounding line, volunteers measure the depth of the site and record the total depth on the sampling form. It is important to know the depth because the instrument sensors must not be allowed to come in contact with the lake bottom.

Step 2: Measure the temperature, dissolved oxygen, and conductivity profile.

The sensor is lowered into the water at the specific intervals designated by county staff, typically at the surface of the lake and at 1-m intervals to the bottom. Volunteers will record readings on the data form.

1. Turn on the YSI-85 DO/temperature meter and allow it to warm up for at least 15 minutes. Turn on the YSI-60 pH meter to start its 15-minute warm up. If "LO BAT" is displayed then you will need to replace the batteries. If pH and temperature are not displayed, press "MODE" until you get to the right display on the screen.
2. Remove the YSI-85 sensor from the calibration chamber on the side of the meter. Shake any water off of it as you would shake down a mercury thermometer. If the sponge inside the chamber looks dry, add a few drops of water, let it soak in, and then pour off the excess. Examine the probe. All holes should be clean of debris, and the gold cathode on the end should be shiny. The plastic membrane over the cathode should not be loose, wrinkled, damaged, or dirty, and there should be no bubbles larger than 1/8" under the membrane. Rinse if needed with purified water. If problems persist, note these on your data sheet and continue as best you can with the procedure. Replace the probe in the calibration chamber, inserting it all the way.
3. Record the time on your data sheet, to the nearest minute.
4. Lower the YSI-85 sensors into the water just below the surface, stirring the water around the sensor by gently "bouncing" the electrode with the cable; allow it to stabilize (should take approximately 1-2 minutes). Have the screen on the meter set to DO mg/L.
5. Record the water temperature, dissolved oxygen level (mg/L and %Sat), and conductivity at that depth.
6. Lower the sensor to the next deeper interval and repeat these steps. Continue this procedure until all depths in the profile have been measured, typically to just off the bottom.
7. Turn off the YSI-85 meter.

Step 3: Measure the pH profile.

1. Remove the YSI-60 sensor from the transport chamber of the meter and lower the probe in the water to just below the water surface. **Make sure the pH sensor at the end of the**

sensor and the temperature sensor near the top of the probe are both immersed in the water.

2. Repeat the profile measurements at the same depths with the pH meter, recording the information on the datasheet. Be sure to allow enough time for the meter readings to stabilize. It may take several minutes. Record pH to the nearest 0.1 pH unit on the datasheet.
3. Shake off the sensor and inspect it for dirt, and insert it back into the transport chamber so that the pH sensor won't dry out.
4. Turn off the YSI-60 meter.

Step 4: Measure the air temperature.

1. Place the air thermometer in a shady spot on the boat with good air circulation.
2. Estimate the reading to the nearest whole degree. Wait about 30 seconds and estimate again.
3. If the reading hasn't changed record the temperature on the datasheet.

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MONITORING AQUATIC PLANTS

Aquatic Plant Condition Parameters

In many lakes across the country, an abundance of rooted aquatic plants impairs the use and enjoyment of recreational waters. A program that focuses on rooted aquatic plants as the lake condition to be monitored should train citizen volunteers to:

- map the distribution of rooted plants;
- determine the relative density of rooted plant types along a transect line running perpendicular from shore in select areas; and
- collect specimens for professional identification.

Mapping the Distribution of Rooted Plants

In healthy lakes, several different species of rooted aquatic plants usually occupy the littoral zone, or the shallow zone near shore. Submergent, rooted floating- leaved, free-floating, and emergent plants are all important for the overall ecology of a lake. Traveling around the shoreline with a lake map, volunteers can draw in the location of significant aquatic plant beds and note where growth has reached the surface. This effort will serve as a historical record for studying changes in vegetative location. In addition, these maps can be useful for planning the application of aquatic plant control methods, such as harvesting.

Determining the Relative Density of Rooted Plant Types

It is often useful to take a closer look at the types of rooted aquatic plants in the littoral zone. A healthy lake usually has many different kinds of aquatic plants. Many lakes, however, have littoral zones that have been disturbed, fertilized, and/or invaded by more aggressive plant species. In these instances, the least tolerant species are often eliminated and one or two more-tolerant species begin to take over the zone. In fact, in the majority of lakes where aquatic plant overgrowths occur, it is the result of a population explosion of only one or two species.

Several exotic plant species (originally from other continents) are notorious for displacing native plants and dominating the littoral zone. They can become major nuisance problems primarily because no natural check and balance system controls their growth. A lack of predators and pathogenic organisms allows exotics to out-compete native species for growing space, light, and nutrients.

The relative density of different plants growing in the littoral zone can be examined by volunteers. The method described in this chapter has volunteers collect plants at specific intervals along a transect line. Additionally, the volunteers are directed to measure the length and depth of the littoral zone along the line.

Identification of Rooted Aquatic Plants

Eurasian watermilfoil (*Myriophyllum spicatum*) and Brazilian elodea (Egeria densa) are examples of exotic (non-native) species that can flourish and cause problems in waters of the United States.

One purpose of a citizen program focused on monitoring rooted aquatic plant conditions on lakes should be to inventory locations where there are significant amounts of plants.

The identification of plant species is important because the effectiveness of lake management techniques differ according to plant type. In many instances, the early detection (and elimination) of aggressive exotic species can save a lake from severe infestation problems later.

Sampling Considerations

The location of sample collection and transect sites in a lake are defined on a lake-by-lake basis from an initial site visit by county staff. Some lakes have extensive weed growth throughout the lake; others have small, well-defined problem areas.

In some lakes, the aquatic plant population is relatively stable throughout the growing season. In other lakes, there is a definite pattern of succession. If the lake is small, volunteers may need to examine plant growth only once or twice a year (in spring and late summer). The program manager may wish to break a large lake with a significant weed problem into segments and send volunteers out every two weeks to sample different areas.

The density, diversity, and growth patterns of aquatic plants are unique to each lake. Therefore, many of the details concerning sample site locations and other program aspects must be worked out by county staff on a lake-by-lake basis.

Sampling Tasks for Monitoring Aquatic Plants

Presented in this section are procedures for mapping the distribution of and collecting rooted aquatic plants, and determining the relative density of plant types along a transect.

Basically, these sampling activities are divided into four main segments.

1. Confirming the sampling date and weather conditions and going through boating safety and sampling equipment checklists prior to launching the sampling boat.
2. Touring the shoreline and mapping the location of aquatic plants at or near the surface.
3. Finding the sampling site, setting up a transect line, collecting plants along that line, and estimating plant densities.
4. Returning to shore and shipping the data forms and plant samples.

County staff should provide volunteers with a sampling schedule and a sampling protocol sheet. Volunteers' common sense and good judgment dictate when it is appropriate to sample. Both good and unacceptable weather conditions should be defined for volunteers during training sessions. Under no circumstances should volunteers be on the water during rain or electrical storms or high winds (white caps), or other unsafe conditions.

Review the Monitoring Sequence:

- Confirm sampling day and weather conditions. Check the sampling date on the program sampling schedule. Check the current and forecasted weather and decide if the conditions allow for safe sampling. The volunteer should also be instructed to confirm this decision after personally inspecting lake conditions prior to launching the boat and beginning the sampling trip.
- Inventory the field kits for completeness before taking them out. Before leaving shore, volunteers must make sure that they have all the needed sampling equipment and supplies on board the boat. Confirm that the following sampling equipment and supplies are on board the sampling boat:
    - Anchor (with a measured line if a depth check is required). Two anchors are helpful on windy days, one off the bow and the other off the stern
    - Weighted sounding line for measuring depth.
    - Calibrated transect line (floating line marked off in meters) with anchor and buoy.
    - Weighted rake with throwing line
    - Plastic bags for plant specimens labeled with the lake name, the date, and the site location Ice cooler (with a closable lid) with frozen ice packs
    - Datasheet, clipboard, and pencils
    - Map of lake with sampling site and landmarks marked
    - Sampling protocol sheet
- Conduct plant mapping survey.
- Collect plant samples.
- Turn in your samples, datasheets, and equipment to county staff.

The Steps for Monitoring Aquatic Plants

Step 1: Map the location of aquatic plants at or near the surface.

For this task, volunteers must take a tour of the shoreline and observe areas of the lake where aquatic vegetation is on or near the surface. Using a clean copy of a lake map, volunteers draw a sketch showing the extent of rooted aquatic plant beds as well as significant landmark features.

Step 2: Estimate plant type density and collect a sample for identification.

Volunteers will locate the sampling site designated by county staff and establish a transect line perpendicular from shore. Following along this line at specified intervals, the volunteer will cast a weighted rake to the lake bottom and pull up aquatic vegetation. This vegetation will be sorted, and the volunteer will make a qualitative estimate of the percentage and density of plant types. Typically volunteers will use the Washington Department of Ecology's Aquatic Plant Identification Manual for Washington's Freshwater Plants. Specimens of each type may be bagged for shipment to a botanist for identification.

(Figure 5. Volunteer with a sample on the weed rake)

1. Find the designated sampling site and tie the end of the transect line securely to a tree or stake at the water's edge.
2. Move the boat away from shore and stretch the transect line to the desired length.
3. Attach the buoy and anchor so that the line remains floating, thus forming the transect.
4. Measure and record the lake depth at the end of the transect using the weighted calibrated sounding line.
5. Move the boat to the first sample point on the transect line.
6. Confirm that the throwing line is securely attached to the weighted rake (can be an
7. ordinary garden rake).
8. Facing the shore, pitch the weighted rake straight ahead (the 12 o'clock position) about six feet from the boat
9. Allow the rake to settle to the lake bottom and then pull the line so that the teeth of the rake drag along the floor of the lake.
10. Bring the rake back into the boat and remove all the vegetation trapped on the teeth. Sort different plant types into separate piles using the manual provided by county staff.
11. Examine the piles and estimate the percentage of each plant type found. Record on the sampling form. The total must add up to 100 percent.
12. Repeat the procedure at the 3, 6 and 9 o'clock positions.

13. After all four samplings are completed, examine the sorted piles and give each plant type a density rating.
    a. If a plant type was found in all four casts and for each cast the teeth of the rake were full, mark 5.
    b. If the plant was found moderately on all four casts, mark 4. If the plant type was found in only three of the four casts, mark 3, and so on.
14. Remove a few healthy specimens from each of the sorted piles of plant types, shake off excess water, and place them in a properly labeled collection bag.

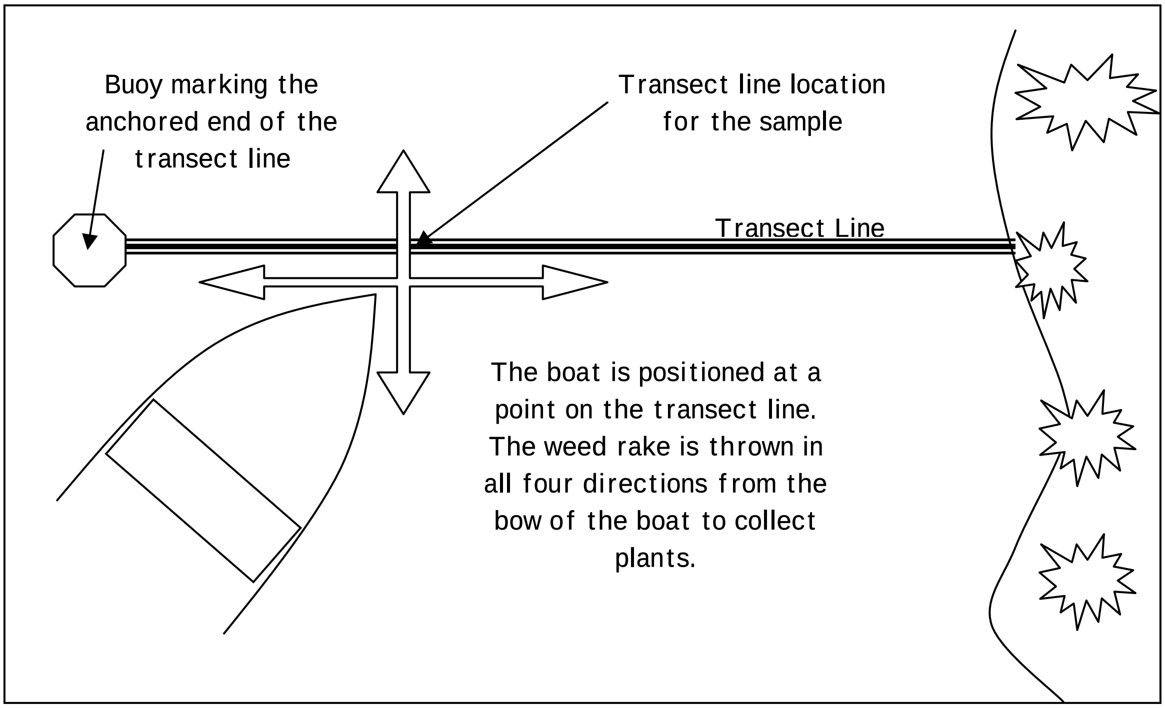

Figure 6. Diagram illustrating how to collect samples at a single point on the transect line.

15. Move the boat along the transect line to the next sampling point and repeat these activities. (The number of sampling points should be determined by county staff.)
16. Keep all collected plant fragments in the boat for proper disposal on land since many nuisance species reproduce from fragments.

Step 3: Cleanup and shipment of samples and forms.

1. The plant rake and ropes should be rinsed off with fresh tap water and the sampling container rinsed with distilled water.
2. Pack and forward the sample cooler with the samples to the laboratory as soon as possible. In addition, the sampling form with the Secchi disk measurement and sampling observations

must be sent to county staff. Check over all field sheets for completeness and clarity before turning them in.

3. Turn in your equipment on time. Leave equipment out to dry if you're storing it at home for a period.
4. Check in your field kits with county staff. Leave notes for staff if equipment needs maintenance, replacement, or calibration.
5. Notify the coordinator of volunteer hours, if applicable.

References

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Appendix A.

Field Data Sheets for Lakes